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Accounting for by-products

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WOOLWORTH BUILDING
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This publication has been prepared by the Research Department of the Association from information received in reply to a questionnaire sent to certain members of the Association on the subject of Accounting for By-products, and from other material in the possession of the Research Department. It has been reviewed by and has the approval of the Committee on Research and Education.

The Research Department would be glad to receive further opinions from members with respect to this interesting phase of cost accounting. The primary purpose of this publication is to place the question before the Association for discussion.

AUGUST 16, 1920

ACCOUNTING FOR BY-PRODUCTS

Scope of this Publication

The points covered in this publication may be broadly grouped as follows:

1. The meaning of the term "by-product."
2. Sources and classes of by-products.
3. The importance of accounting for by-products in modern industry.
4. General factors affecting by-product accounting.
5. The three chief methods of accounting for by-products.
6. Illustrations of accounting for by-products in certain industries.
7. The advantages and disadvantages of each method.

Meaning of the Term "By-Product"

A by-product has been defined as an article of value incidental to the manufacture of the main product of an establishment or made from the waste material arising from such manufacture.

A generally accepted opinion of the meaning of the term by-product, however, does not exist. One authority, for example, draws a distinction between spoilage, waste, scrap and by-products.[1] Spoilage, he says, is always accidental, although a certain percentage of spoilage may be inseparable from certain kinds of work; for example, the making of castings. Waste arises out of the manufacturing operation itself and is generally a variable quantity. This writer goes on to say that scrap is in the nature of a by-product of low grade and is produced in the course of manufacture. He contends that waste has no market value; that scrap has a small value in comparison with the original cost of the material; and that spoilage has value only in as far as the spoiled material can be classed as scrap, all the rest being a loss. He defines by-products as that part of the material which has a value at the

[1] A. Hamilton Church, Manufacturing Costs and Accounts, Chapter IX.—McGraw-Hill Book Co.

time it is rejected from the main processes. If it has no value, he would regard it as waste. So fine a distinction among terms is difficult to apply.[2]

Classes of Defective Work Losses

According to another authority, the losses due to defective work may be classified as follows:

1. Labor and overhead required to salvage defective work.
2. Loss of material where salvaging does not realize full value from the original raw material used.
3. Labor and burden entirely lost when material has to be scrapped.
4. Loss of the material value, being the difference between the original material used and the scrap value of what is spoiled.
5. Loss of profit on account of extra time taken on machines in salvaging material when other new material should have been produced for sale.
6. Loss of profit on material which has to be scrapped.

Items 5 and 6, of course, are not to be computed in the cost records. Nevertheless, a loss of profit due to these causes usually occurs because if it were not for the defective work, other material would be made and sold at a profit.

Classes of Products

One writer states that the products of many plants may be broadly classified into main and by-products. These products may even be called joint ones to indicate that the production factors of any enterprise are jointly required to manufacture them. Main products are sometimes known as primary products; and by-products as additional, minor or residual products.

Classes of By-Products

In the opinion of still another writer, by-products may be obtained from any one or more of the five following sources:

1. Sorting and inspecting raw material—the foreign or defective material not being allowed to enter the manufacturing processes.
2. Residues left after the main product is manufactured.
3. Substances removed in the purification of the main product.
4. Substances extracted which are not necessary to the manufacture of the main product.

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[2]The Committee on Standardization would appreciate receiving the views of members as to the meaning of the terms spoilage, waste, scrap, defective work and by-products.

5. Items not directly connected with or traceable to the material which enters the manufactured product, such as filings, shavings, sweepings, ashes, and exhaust steam.

It is evident that the above classification does not recognize distinctions among the terms spoilage, waste, scrap and by-products.

By-products can be classified also into two groups according to their marketable condition at the time they come into existence, namely: 1. Those that can be sold in their original form without any further expenditures for preparation; and, 2. Those which have to be reworked in order to get them ready for sale.

By-products are found chiefly in the continuous process rather than in assembling industries. Examples of continuous process industries are packing, chemicals, oil, coal and fine cotton. Consequently, by-products are usually accounted for by the process rather than the job cost system because the process system is used in continuous process industries.

Importance of Proper Accounting for By-Products

The problem of accounting for by-products is one of the developments in modern cost accounting brought about by better organization and management. Before the modern methods of reworking and disposing of residues in many of the manufacturing processes were discovered, the manufacturer relegated these residues to the scrap heap, thereby blindly throwing away profits. As the manufacturer found uses for them, some method for their accounting became necessary so that the manufacturer could know his costs in order to meet competition and to manage his business successfully. While as a first step, only the sales and not the costs of by-products may be recorded, it is becoming more and more necessary to record by-product costs if the manufacturer is to decide intelligently whether he should scrap or sell the by-product at the time it arises, or rework it and enhance its sale value.

During the war many manufacturers realized large profits from by-products but kept no record of their cost. In some cases these profits were large enough to pay the regular dividends and, because of this condition, manufacturers in many instances were tempted to increase the production of by-products. When better accounting methods led to recording the costs of the main product and by-product separately, it was often discovered that the extension of the manufacture of by-products turned out to be relatively unprofitable. Many by-products, however, rank nearly as high in importance as the main product. This is true, for example, in the packing, coal, oil and chemical industries.

Before accounting methods are selected for the recording of by-product costs, the management should decide what disposition is to be made of the by-products. Shall the waste be disposed of

as such or reworked into some form of by-product with an enhanced value? An intelligent decision cannot be made without a knowledge of the costs of both by-products and main products. This is the case, for example, in the wood-working and the packing industries. If the by-products in the wood-working industries are charged with their legitimate costs, they often appear in a very unfavorable light. Often more labor and burden are expended in reclaiming material than is warranted by the loss that would result if the material were scrapped in the first place. This is particularly true in the metal industries since the development of electric and oxy-acetylene welding. In the steel industry, for illustration, it frequently is possible to infuse new material in defective places in material being processed, and it becomes a nice problem in many cases to decide whether this should be done. This possibility of using new material often leads to increased carelessness in workmanship because of the feeling on the part of the workers that defects can be easily remedied. It must be decided, therefore, in each case whether the defective work is to be reclaimed, converted into another product, or scrapped.

By-Product Asset Accounts

When a large part of the manufacturing activities of a plant is concerned with the production of by-products, segregated asset and cost accounts must be opened if costs are to be controlled and analysis of cost made possible.

The following list of assets used by one plant in the manufacture of by-products will give an idea of the importance of by-products in that plant:

1. By-product Foundations.
2. Primary Gas Cooler Building.
3. Primary Gas Cooler Apparatus.
4. By-product Building.
5. By-product Apparatus.
6. Booster Building.
7. Booster Apparatus.
8. Ammonia Building.
9. Ammonia Apparatus.
10. Sulphate Building.
11. Sulphate Apparatus.
12. By-product Pump Building.
13. By-product Pump Machinery and By-product Equipment.
14. Surplus Gas Meter Building.
15. Surplus Gas Meters.
16. By-product Platework.
17. Gas Pumper Building.
18. Surplus Gas Line.
19. By-product Piping.

General Factors Affecting By-Product Accounting

After a decision has been reached with reference to the disposition of by-products, the accounting methods for recording them are to be selected. To a great extent the method of accounting depends on (1) the character of the industry; (2) the volume and value of the by-product in comparison with those of the main product; and (3) the desire of the management to get accurate costs with a view to controlling them at their source. It is difficult to lay down any hard-and-fast rules for by-product accounting which can be generally followed, because each plant has individual peculiarities to be considered. The same method of accounting may not be suitable even for two plants in the same industry, because, for one reason, the product may not be processed in the same way.

The accounting for by-products, therefore, presents one of the most perplexing problems in cost accounting. Main products and by-products travel together through the shop up to a certain stage in the manufacturing processes, when a separation occurs. The difficulty in accounting for by-products lies in apportioning costs between the two classes of products up to the time the by-product breaks off or is divorced from the main product. Subsequent to that separation, no serious trouble need be experienced.

General Methods of Accounting for By-Products

Three general methods of accounting for by-products are discussed in this publication. They may be designated respectively as (1) No cost; (2) Preparation for Sale, Selling, and Administrative Cost; and, (3) Total Cost. They are referred to hereinafter as First, Second and Third methods, because the foregoing names are not generally used. The accounting technique in connection with each of them is briefly outlined first; then specific examples of each method are mentioned; and finally the advantages and disadvantages of each are discussed.

First Method of By-Product Accounting

The first method of by-product accounting, which probably is used more than any other, is to record only the sales and sales returns of by-products. One general account or a separate account for each by-product may be kept, depending on the variety of by-products sold, and the extent to which the management wishes to go in obtaining data for analysis. The excess of sales over sales returns—that is, the net sales—is usually closed into the current profit and loss account, and entered in the "Other Income" or "Miscellaneous Income" section of the profit and loss statement instead of being treated as a reduction of "manufacturing" costs. This method may therefore be called the "No Cost" method, because the manufacturing costs, and the selling and administrative expenses of the by-products are not separated from the costs and expenses of the main products.

Second Method of By-Product Accounting

The second method of accounting for by-products differs from the first in that it records the cost of making by-products salable after they have split off from the main product, the expenses of selling them and the portion of administrative expense applicable to them. The advantage of the second method over the first, is that it gives more information, but neither the first nor the second method indicates the manufacturing costs of the by-products prior to the time they separate from the main products.

Third Method of By-Product Accounting

The chief feature of the third method of by-product accounting is that it separates the costs of by-products from the costs of main products, from the very first manufacturing step. Under the first two methods, the costs of main products and by-products are combined until the point of physical separation is reached. In many cases, however, it is difficult to calculate precisely the costs of by-products prior to physical separation and consequently, even under the third method, arbitrary initial cost values must often be assigned to by-products. In some cases these values are regarded as only the "material cost of by-products." They may, however, be the manufacturing costs if the by-products require no further treatment before sale. Under the third method, perpetual inventories of by-products are kept, which will show quantities and values. The method should not be adopted unless it will be practicable. This depends upon the degree of accuracy which can be attained without needless "hair-splitting" over details, and upon the relative value of the by-products in comparison with that of the main product.

Illustrations of First Method

The salient features of the accounting for by-products under the three methods have been described. Some specific illustrations of the different methods will now be discussed.

The first method is sometimes used for certain products in the chemical industry. In order, for example, to make a certain intermediate product, it may be necessary to make one which has little salable value without another manufacturing operation. When this operation has been performed, it may leave one part of the product that can be used in further processes, and another part with slight value in its present form. In this case the whole cost of the last operation is sometimes added to the cost of the first part. The second part of the product is sold as a by-product and its sale is recorded separately, but no manufacturing costs for it are recorded in the books.

If, taking another illustration, the manager of a machine shop wishes to show separately the cost of main products and the cost of by-products, then theoretically even turnings and borings should be credited to the costs of parts being machined. This, however,

is rarely feasible because of the clerical work involved, and consequently only the sales, and not the costs of turnings and borings, are usually recorded.

Many by-products are of such relatively slight value and importance that the only practical method of accounting for them is to treat the proceeds of their sale as an item of miscellaneous profit. Although, in theory, they should be credited to the costs of the department which produces them, any benefits derived from this procedure would be offset by the cost of the clerical work involved.

First Method as Used in the Shoe Industry

A modification of the First Method is usually well adapted to the "Outsole, Innersole and Top Piece Cutting" department in a shoe factory, where stock such as outsoles, innersoles and heel top pieces are cut from leather. In this case, the by-product consists of damaged or undergrade main products, such as brands, heads, heeling, and half-heeling. At the beginning of a season, each one of the by-products is given an estimated value based (1) on the total value of shoes to be manufactured under contract, and (2) on the estimated market values during the season. As each lot of leather is cut up during the season, a cost sheet is opened on which is entered the total cost of material cut up and the quantity of good and defective pieces obtained. The fixed estimated value of the by-products is then deducted from the cost of the material cut up, the difference being the net material cost of the main product. In this case, the fixed estimated value of the by-product is not adjusted to record its actual cost. The labor and expense incurred in cutting and handling the material is assumed to be included in the fixed estimated value of the by-product material.

In the opinion of one writer, one of the reasons for this accounting treatment is that all the by-product is considered as waste which has a sorting value different from the main product. The profit or loss on the sales of by-product and main product, however, is recorded separately. Another reason for the above accounting treatment may be that the management wishes to keep the cost and volume of by-products to a minimum—the by-product being regarded as waste. In one shoe factory, the by-product was not more than 8% on all bottom stock cutting.

While this method of by-product accounting, whereby the proceeds received from the sale of the by-product are deducted from the manufacturing cost of the main product, is common, it nevertheless is unsatisfactory. It is even more erroneous to credit the proceeds to the overhead of the department which produces the by-product, because this method does not reveal either the correct costs or the "miscellaneous income" from the sales of by-products. Under this procedure, the sales figure is treated as

a reduction of the cost of main product. Hence both the costs and profits of by-products and main products are incorrectly recorded.

Illustration of Second Method

The second method of accounting for by-products is sometimes used in coke plants, where the principal by-products are gas and ammonia. The main product, coke, is charged with all costs up to the time the first by-product is extracted. Thereafter, the costs of the main product and the by-products are recorded separately. To be more exact, losses in weight of the coal consumed in the production of coke should be charged to by-products as a material cost. For example, if 100 tons of coal were consumed in producing 80 tons of coke, the cost of 20 tons should be charged to the by-products.

Summary of Third Method

Under the third method, by-products generally are charged with (1) material, at an arbitrary value if necessary; (2) labor expended on the by-product after it separates from the main product; (3) an equitable proportion of overhead, and (4) a proper share of selling and administrative expense, when these items are applied to the various products or classes of products on the basis of manufacturing costs.

Illustrations Showing Calculation of Material Costs of By-Products

The third method is used in the packing, steel and oil refining industries. Under it, the material costs of by-products may be ascertained, with varying precision, in several ways.

(1) The material cost can be accurately calculated if the business could, if desired, buy the material for the main products and by-products separately. In this case the approximate profit of the vendor is deducted from the purchase price of the material in order to ascertain the material cost to be recorded in the buyer's books.

(2) Arbitrary values can be assigned to residuals (by-products) extracted from the main products, if the residuals when extracted have a market value; such, for example, as a chemical of low degree of strength or concentration which is to be converted into another form. No part of any profit that might have been made if the residual were manufactured independently and not extracted, is included in the cost of residual. While the value of the by-product at the time it splits off from the main product is usually regarded simply as material cost, it consists in part of labor and overhead incurred prior to the time the by-product breaks off from the main product.

(3) The arbitrary values used, instead of being market values, may be those which are apportioned between the main products and the by-products, when the two classes of products are capable of comparison by a *common standard*, such as the

number of British thermal units. Such a comparison may be made, for instance, in plants which carbonize coal in order to get coke, the gas obtained being regarded as a by-product; or in factories where gas is the main product and coke is the by-product. Since the values of both products in these two cases are large, serious attempts should be made to approximate the values of each class in order to fix proper selling prices. Other units of comparison are board feet, used in the case of certain lumber industries; weights, used in the case of certain rubber products; and tons, used in petroleum refineries.

(4) If the value of material in by-products cannot be closely determined by any one of the three methods described above, it can be estimated by the procedure known as "working backward." This may be illustrated as follows:

COST OF MAIN PRODUCT UP TO SPLITTING OFF POINT

Material	$10,000	
Labor	8,000	
Burden	6,000	
Total		$24,000.00
Value of By-product per By-product Statement Shown Below		4,220.00
Net Cost of Main Product		$19,780.00

SUBSEQUENT COST OF MAIN PRODUCT

Value at Split Off Point		$19,780.00
Material	$1,000	
Labor	1,200	
Burden	800	
		3,000.00
Final Cost of Main Product		$22,780.00
Unit Cost of Main Product (300 units)		$75.93

COST OF BY-PRODUCT

Selling Price		$6,000.00
Deduct:		
Gross Profit, 10% of Selling Price	$600	
Administrative and Selling Expenses, 3% of Selling Price	180	
		780.00
Net		$5,220.00
Material, labor and burden cost from time of split off		1,000.00
Value at time of split off, to be credited to cost of main product		$4,220.00

SUBSEQUENT COST OF BY-PRODUCT

Value at split off point		$4,220.00
Material	$400	
Labor	500	
Burden	100	
		1,000.00
Final Cost of By-product		$5,220.00
Unit Cost of By-product (100 units)		$52.20

Variation of Third Method

Many materials can be purchased with or without certain by-product contents. For example, there are ores which contain a major metal content and also one or more minor metals as by-products. A company desiring the major metal content may purchase the ores before or after the minor metal contents have been extracted. If raw materials which include by-products are purchased and the by-products are thereafter extracted, the material cost of the main product should get the full benefit of the charge to the by-product because the extraction of the by-product entails charges, such as labor and incidental supplies, which would not have been incurred if the raw materials had been purchased after the extraction of the by-products.

From the viewpoint of the total production cost, the point at which costs of the main products should be credited with the by-products is not of importance. If costs of by-products and main products are to be shown separately, however, labor and overhead as well as material costs should be recorded.

Methods of Calculating Labor and Overhead Costs of By-Products

In some cases attempts are made to calculate labor and overhead costs of by-products as well as the material costs. Accurate charging of labor and overhead may be more difficult than the charging of material. Sometimes labor and overhead are apportioned between the main products and by-products according to the weight or bulk of each class. In other cases, labor and overhead are distributed over main products and by-products according to respective selling prices. Obviously, a time basis for distribution cannot be used in cases where the main products and by-products have been in process for the same length of time.

Time of Separation of By-Products from Main Product Affects Accounting

The separation of by-products from main products may be natural or artificial. If the separation can be controlled, the management must decide when to effect it. This managerial decision has a vital bearing on the cost accounting. For example, if for the sake of convenience in manufacturing the main product, the separation is not effected when first possible, then all the manufacturing costs subsequent to the earliest time when the separation could have been accomplished should be charged to the main product.

Objections to First Method

Executives sometimes are not anxious to recognize that by-products have a value, because of royalty complications. Their contention is that the manufacture of by-products and main products together requires more capital than the manufacture of main

products alone. Consequently, they believe that anything obtained from the sale of the by-product is wholly profit, and should not be credited to the manufacturing cost of the main product.

One cost accountant contends that the manufacturing cost of the main product should not be credited with the proceeds received from the sale of by-products because the entries necessary in this case could not be made in the particular month when the operations on the by-products are performed. Therefore, he says, the above procedure would show a false cost. He claims, further, that where gross profits are shown yearly or periodically by products and departments, nothing worth while would be accomplished by crediting the sale of by-product to the main product, even though feasible.

Other objections to the first method are the following:

(1) The accounts do not reveal the separate costs of the main products and by-products. As a matter of fact, no attempt is made to calculate or even estimate the costs of by-products. These costs are buried in the accounts which show the manufacturing costs of the main products.

(2) The selling and administrative expenses necessary to dispose of the by-products and main products, are not segregated.

(3) In the absence of manufacturing, selling and administrative costs, it is absolutely impossible to separate the losses or profits on by-products and main products.

Because of the deficiencies of the first method, selling prices cannot be fixed intelligently, and manufacturing policies cannot be based on facts.

Despite objections to this method of accounting for by-products, however, it may be the only practicable one for many plants, particularly small ones, where the separation of the costs of the main products from the costs of the by-products involves too much clerical work, or where no clearly defined basis of separation appears.

Criticism of First and Second Methods

Two very marked objections to both the first and second methods of by-products accounting in certain cases are that in the first place no physical inventories of by-products are taken; and in the second place no stock record sheets are kept for by-products. This failure to observe two fundamentals of cost accounting precludes the possibility of even approximating by-product costs. Still another objection is that entries for by-products are not recorded at the time of production, but only at the time of sale. As a result,

a true cost history of the by-products does not exist. Because of these conditions, the first and second methods are conducive to loose and faulty accounting, and even to fraud. When adequate records for by-products are not maintained, workmen and, in some cases, executives have sold by-products and appropriated the proceeds for their own personal use. Furthermore, with inadequate accounting, no reductions in the manufacturing costs of main products are shown by the records, although the manufacture and sale of by-products does decrease the costs of the main products.

Advantages and Disadvantages of Second Method

The second method is applicable when the by-product has no salable value at the time it is divorced from the main product. But if it can be worked up into a marketable condition by incurring additional labor and overhead, these costs should be charged against it and deducted from the selling price in order to arrive at the profit. This method is applicable also to industries where the carrying of the by-product along with the main product prior to the separation of the two does not add appreciably to the cost of the main product. The second method of accounting for by-products is more accurate than the first, but it is not a great improvement, because the costs as recorded are not sufficiently complete to be of much practical use.

If the by-product is of so little value at the time it arises that it normally would be dumped, it often is manufactured and sold practically without profit in order to eliminate the cost of dumping. In that case, only the cost of getting the by-product into salable state should be charged to it.

If the manufacturer allows the by-product cost to remain as a part of the manufacturing cost of the main product, it means that the by-product at the time of separation would have no recorded cost value. If the by-product then is sold at market prices, the profit thereon will be overstated in the accounts because no cost value was placed on the by-product when it was divorced from the main product.

If this accounting method is followed, the selling price of the main product should, of course, be sufficient to cover the cost of the by-product and to provide a profit.

The following example illustrates the fact that the method of accounting for by-products may have a vital bearing on business policy: Suppose two competitors, A and B, are manufacturing the same line of furniture. Assume that A credits the manufacturing cost of his main product with an arbitrary value placed on his by-product, while B allows the value of the by-product to remain as part of the manufacturing cost of the main product. In this case the manufacturing cost of A's main product will be less than B's, and A might reasonably sell at a lower figure. Each would

doubtless argue that the other's accounting methods are faulty. Unless A disposes of his by-product at a profit, he may incur a considerable loss.

Advantages and Disadvantages of Third Method

In many plants the tendency is to charge as little cost as possible to the by-product on the theory that it is entitled to the free use of the shop's equipment. Nothing could be more fallacious. No portion of a factory's output should be favored over any other. All output should be charged with its legitimate costs. This can be done correctly only under the third method of accounting. Another advantage of this method is that inventories can be priced more accurately.

One objection to this method, when the by-product cost is taken at market prices, is that the material cost of main products will be distorted by market fluctuations. An increase in the price of by-products due to a scarcity of or a large demand for them would reduce the cost of the main products because of market conditions which might be only temporary. For example, because of a temporary shortage, the price of sulphuric acid made by zinc manufacturers increased approximately 400% during the war. If the market price of the by-product varies in exact ratio with the market price of the main product, it is contended that no serious objection can be raised to using market prices in recording the material cost of by-products.

In some cases, a definite ratio is established between the cost of the raw material which enters the main product and the value placed on the by-product. For example, if the cost of raw material entering the main product is $20 per ton, the value set on the by-product may be $5 per ton. Now, if the price of the raw material increases to $30 per ton, the by-product can be charged and the main product credited at $7.50 per ton. This method should be followed if a large part of the profits are made on by-products, the price of which may increase disproportionately with the price of main products.

It should be remembered that the manufacturer of by-products usually expects to receive for them a price which will cover the cost of labor and overhead and allow a reasonable profit. Therefore, if the selling price covers these items, it is contended that no value should be placed on the material in the by-product for the purpose of reducing the cost of the main product. In cases of this kind, it might be well to consider the advisability of selling the waste material as scrap instead of working it into a marketable condition, unless the by-product is run to "get the machine time," that is, to absorb expenses which would otherwise have to be borne by the main products.

The argument that the utilization of waste material which otherwise might be thrown away does not decrease the cost of the main product may be met, however, by pointing out that just as the saving of labor or power by improvements in the process reduces the costs, so should an economy effected by putting into a by-product a material which cannot be used in the regular production reduce the cost of the main product.

If the by-product when it arises can itself be used in the further manufacture of the main product in place of material that could be bought in the open market, then the by-product is sometimes charged to the main product at the market price of the material for which it is used in substitution. Where, however, there is no equivalent material to be purchased on the open market, the best accounting method is to charge the main product with the manufacturing cost of the by-product. This eliminates the criticism that inventories of the main product are inflated if the main product is charged with the sale value of manufactured by-products that might include a profit, instead of with the manufacturing cost of the by-product.

The following objections have been made to this third method:

1. In some cases it involves too much clerical work.
2. It is difficult in many cases to determine the cost of the by-product even approximately.

In addition to these specific objections, a manufacturer may take the attitude that the cost of the main product is not really affected by the cost of the by-product. Further, there is the fear in some quarters that a reduction in the book cost of the main product, through credits for by-product costs, might lead customers who learned of it to demand a lower selling price for the main product.

On the whole, however, the third method is more logical and it gives information which is of vital importance in the administrative control of the business. A majority of the members of the Association who expressed their views on this matter stated their preference for the third method.